Ⅳ－144 EFFECTS OF LINK COST FUNCTION ON NETWORK PERFORMANCE

Zakaria MOHAMAD : Student Member, Ehime University.
Yasuo ASAKURA : Regular Member, Ehime University.
Masuo KASHIWADANI : Regular Member, Ehime University.

1. INTRODUCTION

The process of determining a pattern of traffic flows on a network of roads for a known set of interzonal movements, in accordance with stipulated speed-flow relationships on the links is called "capacity restrained" assignment.

This paper aims to compare two types of speed flow relationship used in the capacity restrained traffic assignment method. For this purpose, the BPR and the Davidson's link cost function are used with the "Incremental Assignment" to find out the effect of these functions to the overall network performance.

2. LINK COST FUNCTION USED IN THE ASSIGNMENT.

For both functions the following notations are used ; T : time, T_0 : free flow travel time, V : link flow, and C : capacity.

2.1 BPR Link Cost Function.

In its general form, the Bureau of Public Roads link cost function is written as,

$$T=T_0\{1+\alpha(V/C)^{\beta}\} \qquad (1)$$

where α and β are parameters which were suggested by BPR engineers as 0.15 and 4.0 respectively. The parameter $1+\alpha$ is the ratio of travel time per unit distance at practical capacity C, to that at zero flow.

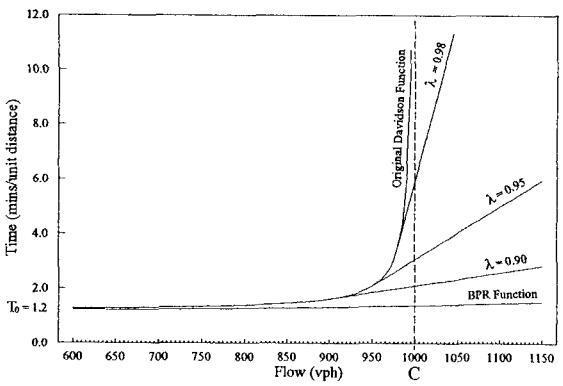

Fig. 1 : Davidson (original and modified) and BPR Link Cost Functions.

2.2 Davidson Link Cost Function

The function has appeal due to the existence of theoretical justification using queueing theory, and written as follows.

$$T=T_0\left\{1+J\left(\frac{V}{C-V}\right)\right\} \qquad (2)$$

where J is a delay parameter that vary with route type and location in metropolitan area. As study done by D.E.Boyce, B.N.Janson and R.W.Eash (1979), the parameter J was considered as 0.04 for the network with arterial street and without severe jam at intersection.

In this function, travel time increases to infinity as link flows approaches capacity. In the incremental assignment the flow assigned to the links may exceed the maximum capacity causes the computational difficulties, so the function is modified as follows.

The gradient of the function at $V=\lambda C$ where $0 < \lambda < 1$, can be written as,

$$\frac{dT}{dV}=\frac{T_0 J}{C(1-\lambda)^2} \qquad (3)$$

Then the resulting Davidson link cost function is,

$$T=T_0\left\{1+J\left(\frac{V}{C-V}\right)\right\} \qquad \text{for } V \le \lambda C \qquad (4)$$

and,

$$T=T_0\left\{1+J\left[\frac{(V-\lambda C)}{C(1-\lambda)^2}+\frac{\lambda}{1-\lambda}\right]\right\} \qquad \text{for } V \ge \lambda C \qquad (5)$$

The flow-time relationship at linear function is relatively depending on the parameter λ. Fig.1 shows

the shape of the flow-time relationship for original function and modified function with λ=0.90, 0.95 and 0.98. In this paper λ is taken as 0.95 to consider the realistic of flow-time relationship at over loaded region.

3. NETWORK

The test network used is symmetric as shown in Fig. 2. The network contains 25 centroids and 80 links with three types of capacity ranging from 1000 vph to 3000 vph. Total trips of 3375 trips/hr were assigned to the test network. Two types of Origin and Destination matrix pattern were tested to the functions; i) Uniform OD pattern, $OD(i,j)=56$ trips/hr ii) Concentrated OD pattern which indicate the peak hour OD pattern from surrounding zones to city center, $OD(i,j)=50$ trips/hr for $j\neq13$ and $OD(i,13)=206$ trips/hr.

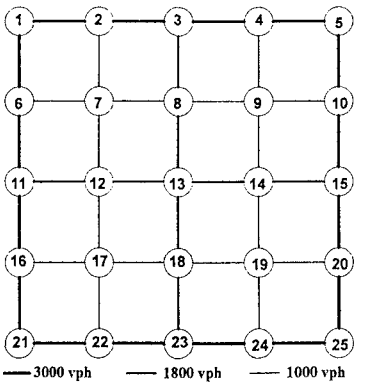

Fig.2: Test network

4. RESULTS AND DISCUSSION

Table 1 shows the summary of network travel time statistics for uniform OD and concentrated OD pattern. The selected links characteristics from two types of OD pattern assignment for each function are compared in Table 2.

Comparing the two functions, Table 1 shows that the total travel time and standard deviation for assignment using Davidson link cost function is much higher. These characteristics indicate that the times resulting from the use of the Davidson link cost function are unrealistically high especially for the congested network assignment by which the loading of links near capacity occurred. In the case of modified Davidson link cost function used in this assignment, the drastic change in time at near link capacity is relatively depending on the value of λ.

Table 1 : Summary of travel time statistics.

TRAVEL TIME	UNIFORM OD		CONCENTRATED OD	
	BPR	Davidson	BPR	Davidson
Total network travel time (veh-hr)	2356.5	2662.5	2323.8	3372.0
Average link travel time (mins/unit dist)	1.26	1.42	1.27	1.84
Standard deviation (mins)	0.0465	0.1550	0.0749	1.0312

Table 2 : Selected links comparisons

LINK	UNIFORM OD						CONCENTRATED OD					
	Link Volume		Time (km-hr)		V/C Ratio		Link Volume		Time (km-hr)		V/C Ratio	
	BPR	David	BPR	David	BPR	David	BPR	David	BPR	David	BPR	David
1 - 2	1530	1536	30.6	32.3	0.51	0.51	1438	1476	28.8	31.0	0.48	0.49
2 - 1	1530	1536	30.6	32.3	0.51	0.51	1360	1398	27.2	29.3	0.45	0.47
2 - 3	2499	2511	52.5	60.3	0.83	0.84	2237	2509	47.0	60.2	0.82	0.84
2 - 7	721	714	15.1	15.7	0.72	0.72	725	731	15.2	16.1	0.73	0.73
3 - 2	2499	2511	52.5	60.3	0.83	0.84	2466	2282	51.8	52.5	0.75	0.76
3 - 8	1124	1124	22.5	23.6	0.62	0.62	1455	1425	30.6	32.8	0.81	0.79
7 - 2	721	714	15.1	15.7	0.72	0.72	719	724	15.1	15.9	0.72	0.72
7 - 8	908	903	20.0	24.4	0.91	0.90	1027	1041	23.6	67.6	1.03	1.04
8 - 3	1124	1124	22.5	23.6	0.62	0.62	842	815	16.8	17.1	0.47	0.45
8 - 7	908	903	20.0	24.4	0.91	0.90	943	955	20.8	35.3	0.94	0.95
8 - 13	1622	1610	35.7	43.5	0.90	0.89	2077	1965	51.9	161.1	1.16	1.10
13 - 8	1622	1610	35.7	43.5	0.90	0.89	1140	1022	22.8	21.5	0.64	0.57

Table 2 shows the comparisons of link volumes, V/C ratio and km-hour of both function for each OD pattern. The difference of link flow between two functions is small particularly in the case of uniform OD pattern but the flow assigned using BPR link cost function is increased for concentrated OD pattern. The time (km-hour) is comparatively large for both types of OD pattern when using Davidson link cost function.

Link volumes and V/C ratio for uniform OD pattern as compared in Table 2 produce roughly comparable results, but the difference of the two functions in the way the trips distributed to the network can clearly be observed in the case of peak hour OD pattern assignment. The flow assigned by using BPR function for link 8 - 13 is higher showing the users used the same congested link toward city center rather diverted to other uncongested link. The link flow result of using Davidson function is slightly realistic than BPR function for the congested network assignment. Overall change in network performance will also be effected by J parameter of Davidson link cost function and α & β of BPR link cost function.